Making sense of the ridge in pp and pA

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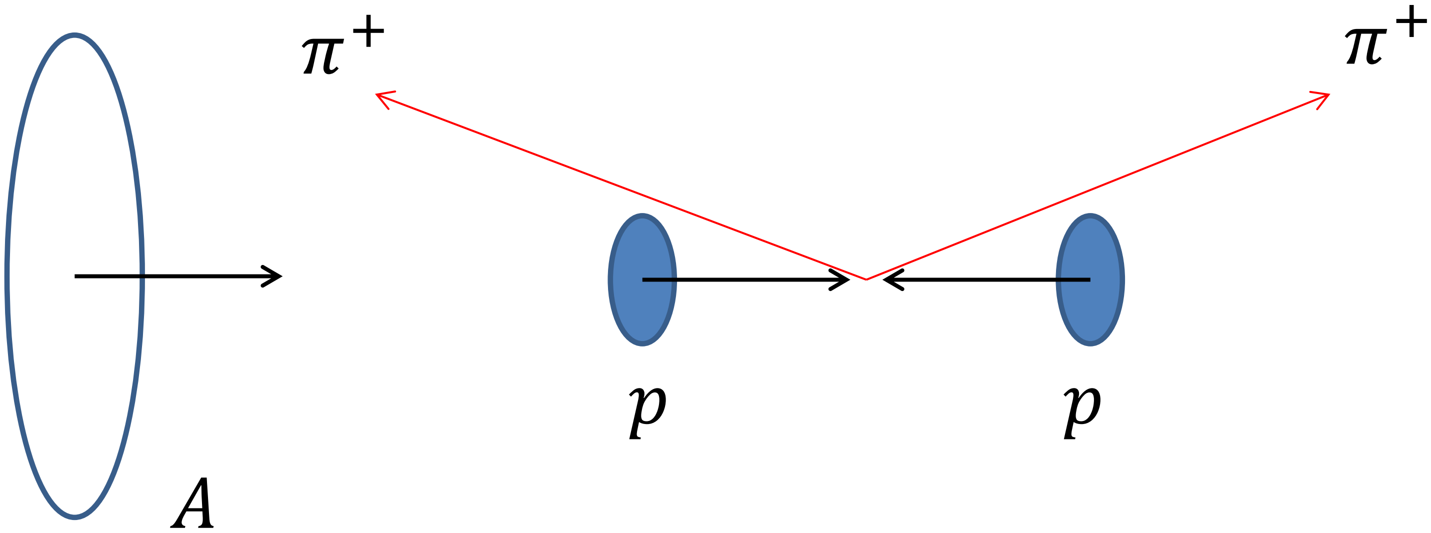
Outline

- Introduction
- CGC and hydro
- Scaling by PHENIX
- 4-particle correlation
- HBT radii
- Conclusions

The observation in pp, pA and dA collisions

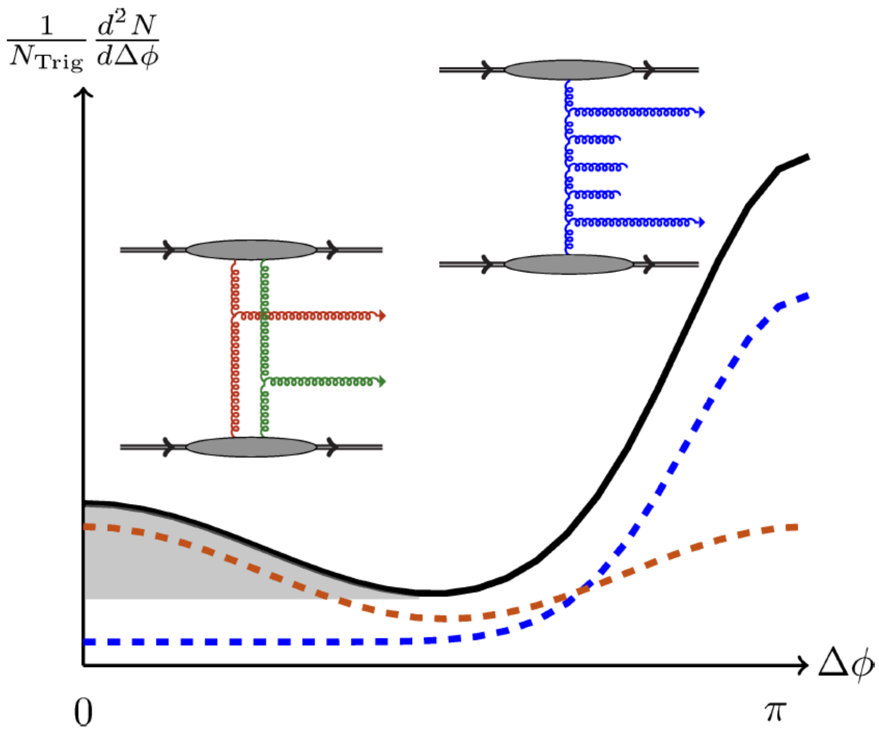


In high multiplicity events these particles (with large rapidity separation) prefer to have <u>the same</u>, or opposite, azimuthal angles

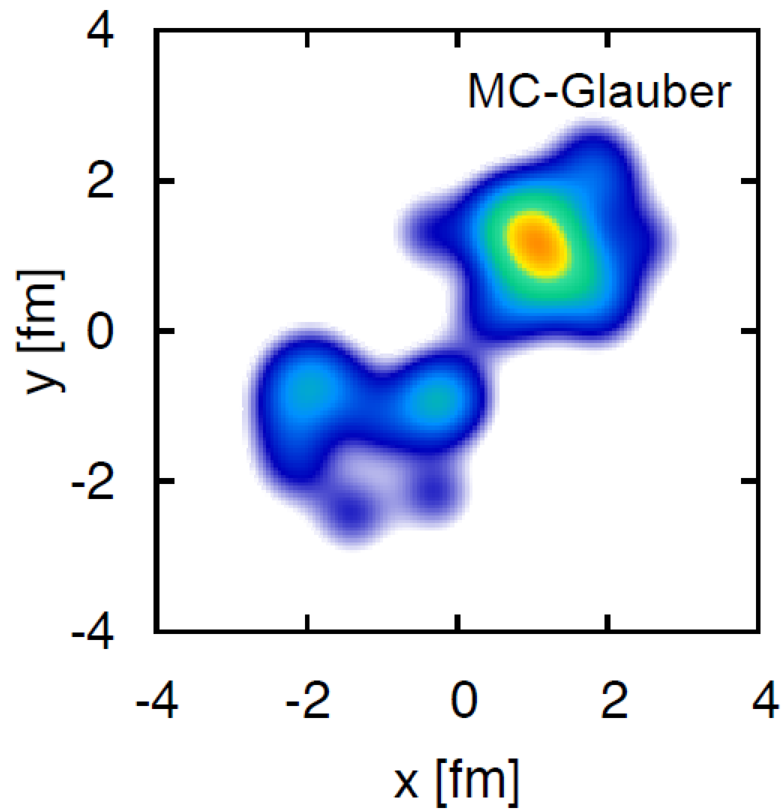
$$C_2(\varphi_1,\varphi_2,p_1,p_2) \sim \mathrm{c}(p_1,p_2) * \cos(2[\varphi_1-\varphi_2])$$

CMS, JHEP 1009 (2010) 091; PLB 718 (2013) 795
ALICE, PLB 719 (2013) 29; ATLAS, arXiv:1212.5198; PHENIX, arXiv:1303.1794

CGC



Hydrodynamics

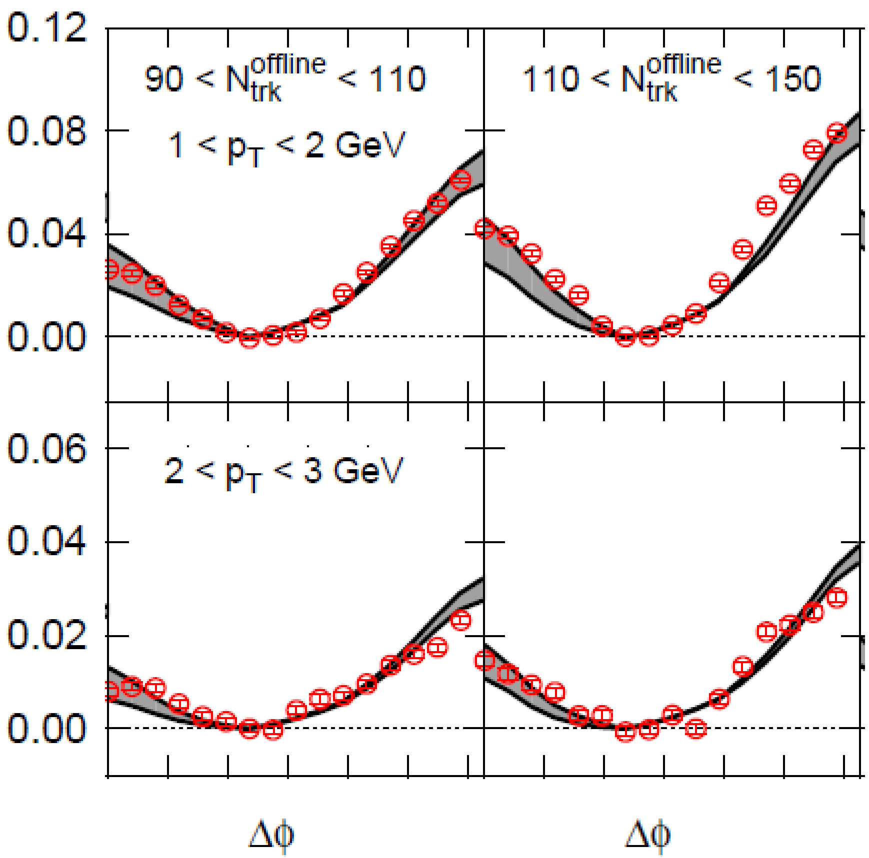


In both cases:

$$C_2(\varphi_1, \varphi_2, p_1, p_2) \sim \mathrm{c}(p_1, p_2) * \cos(2[\varphi_1 - \varphi_2])$$

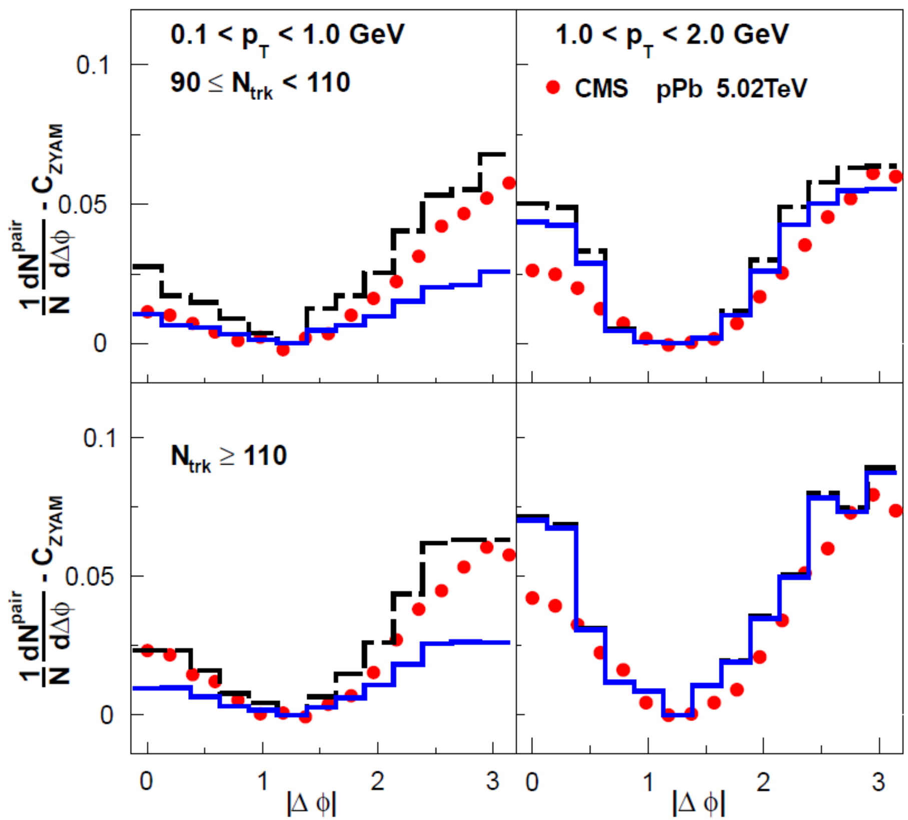
with an approximate factorization: $\boxed{\mathrm{c}(p_1, p_2) \approx s(p_1)s(p_2)}$

CGC (a sample)



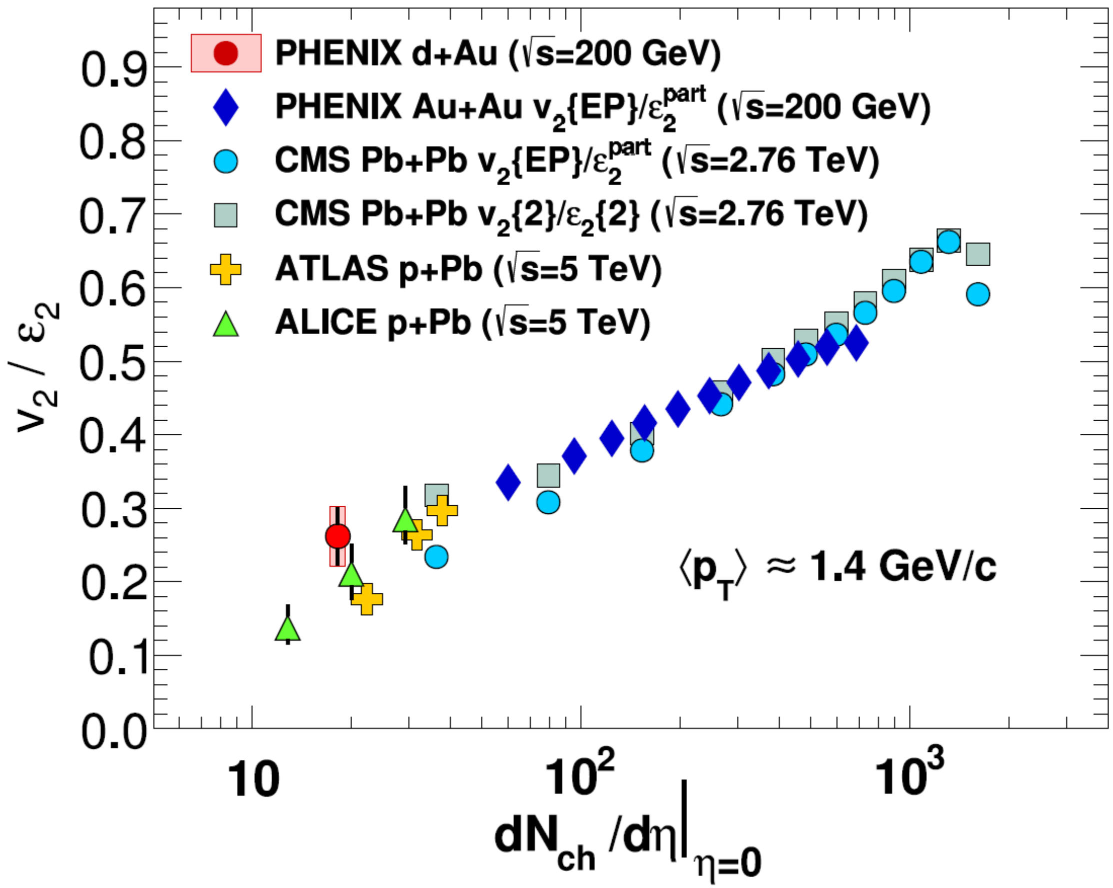
K. Dusling, R. Venugopalan, arXiv:1302.7018; arXiv:1211.3701; PRL 108 (2012) 262001

Hydrodynamics



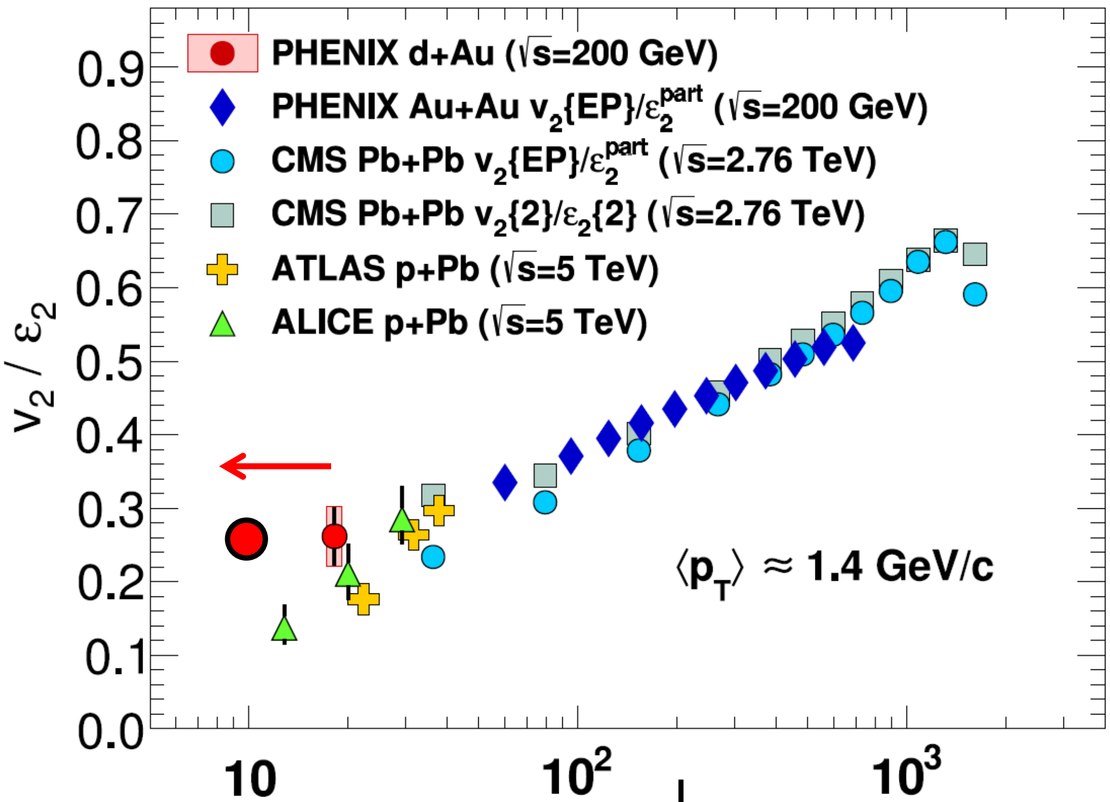
P. Bozek, PRC 85 (2012) 014911
P. Bozek, W. Broniowski, PLB 718 (2013) 1557

Scaling by PHENIX



PHENIX: “It also suggests a relationship to the hydrodynamic understanding of v_2 in heavy ion collisions”

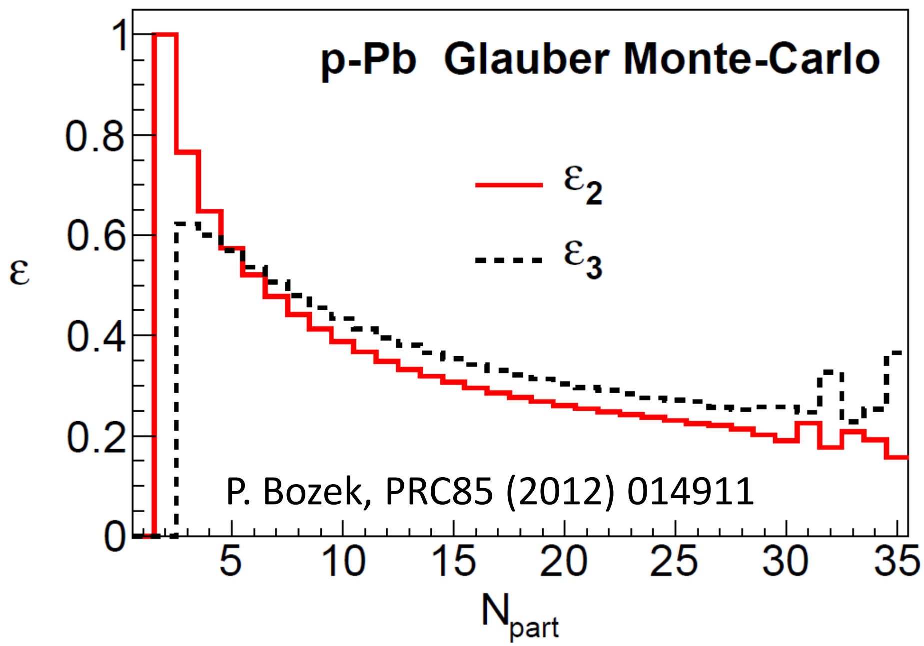
… but let’s look closer



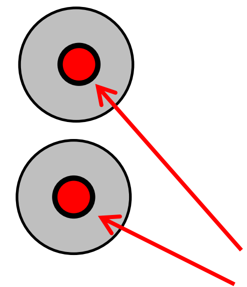
$$\frac{dN_{ch}/d\eta|_{\eta=0}}{S_\perp} = \text{density}$$

d+Au point shifts to the left by at least a factor of 2 in comparison to p+Pb

… and what about ε_2 used in this plot



In pA the standard Glauber model is not good:

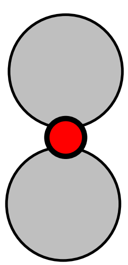


$\varepsilon_2 = 1$

$\varepsilon_3 = 0$

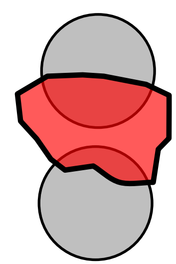
deposition of energy in pp collisions

Why not to deposit energy in the center?



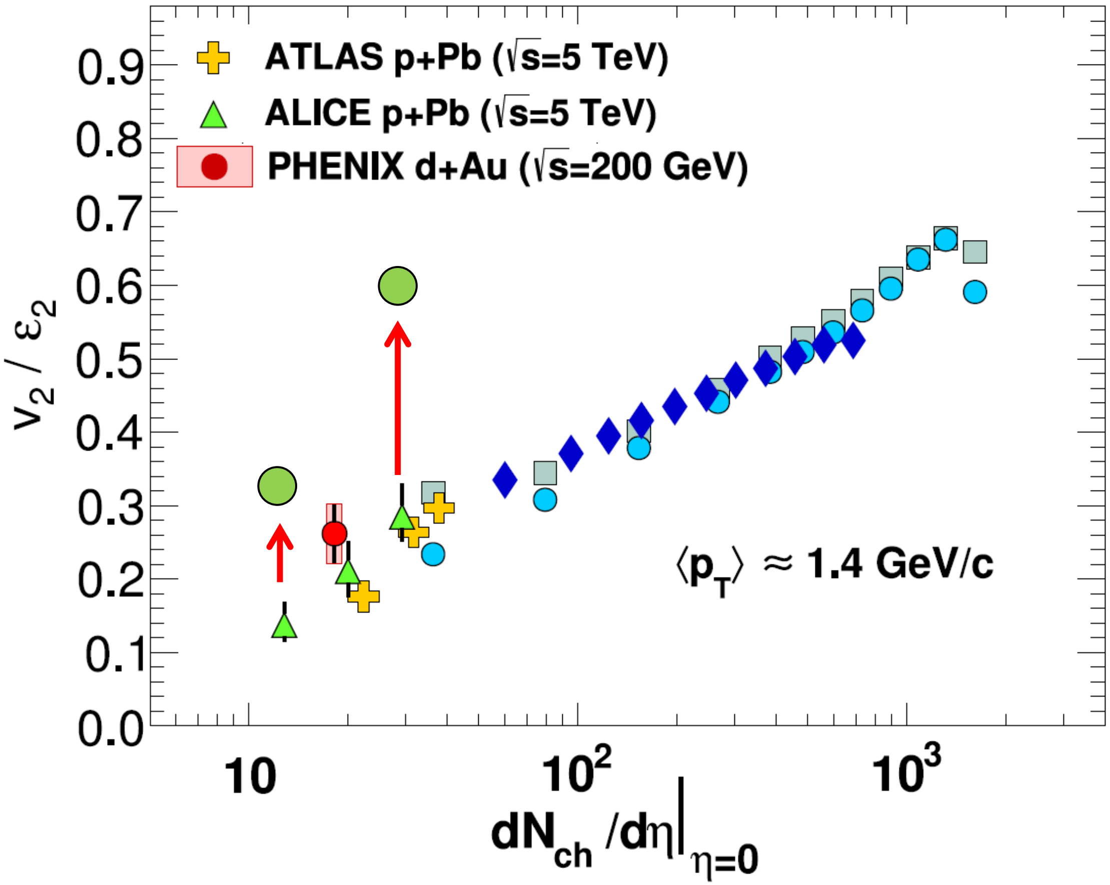
$\varepsilon_2 = 0$

Why not to use something realistic?



$\varepsilon_2 \sim 0.3$

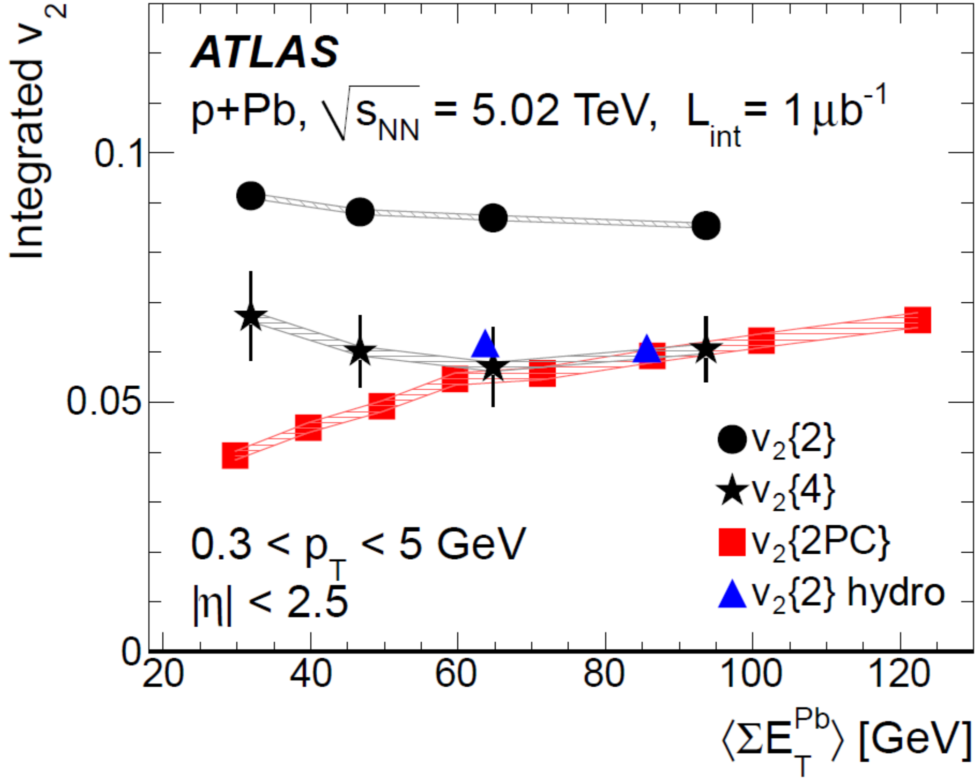
We find that standard Glauber overestimates ε_2 in pA by a factor of 2 to 4. In AA these details are less important



This is also important in hydrodynamic calculations of pA

ATLAS result

arXiv:1303.2084v1



$$C_2(\varphi_1, \varphi_2) \sim (v_2\{2\})^2 \cos(2[\varphi_1 - \varphi_2]) + G_2(no\ \varphi)$$

$$C_4(\varphi_1, \varphi_2, \varphi_3, \varphi_4) \sim (v_2\{4\})^4 \cos(2[\varphi_1 + \varphi_2 - \varphi_3 - \varphi_4]) + G_4(no\ \varphi)$$

It is easy to show that if multiplicity distribution is given by negative binomial (present in CGC) then

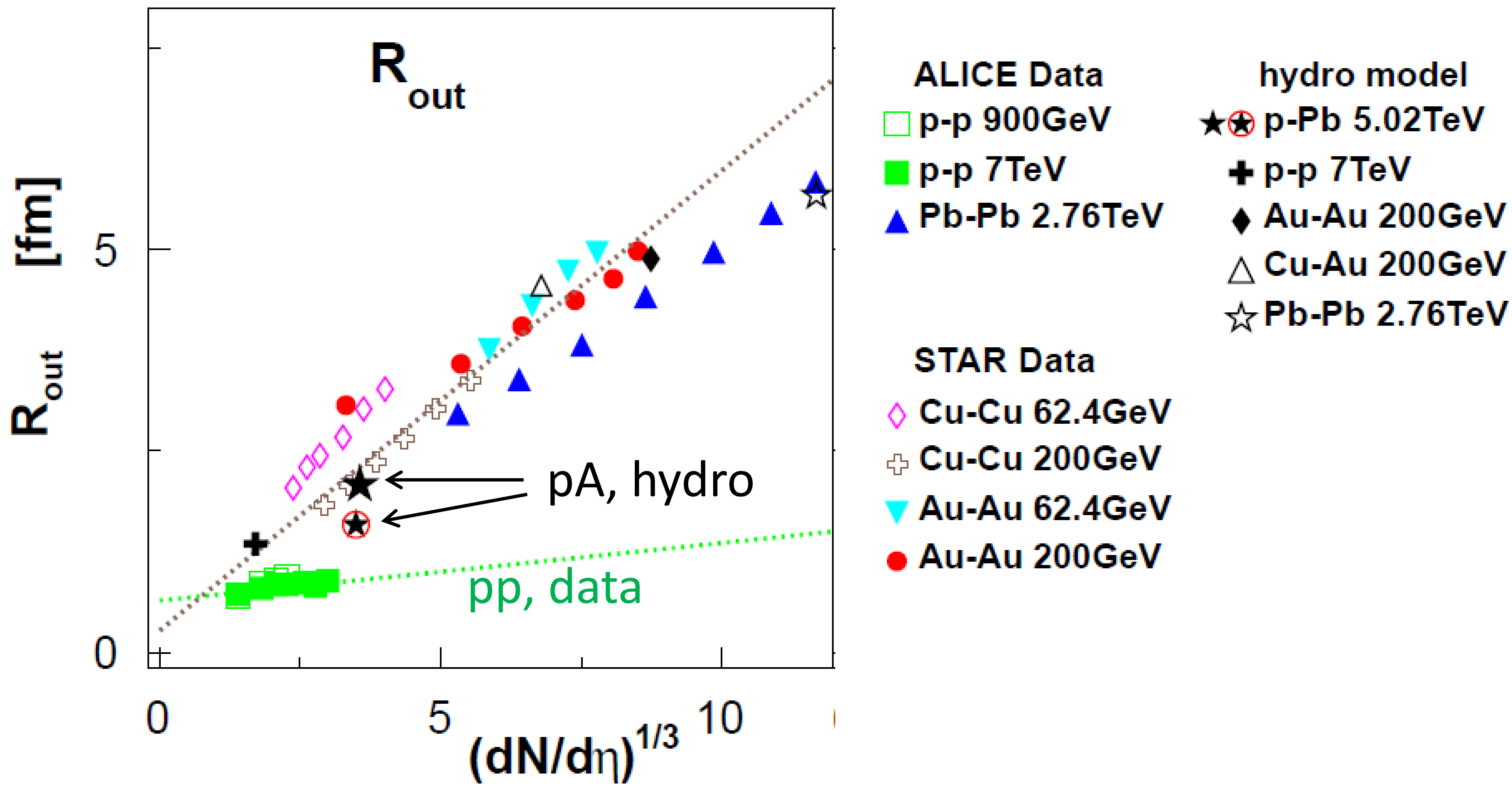
$$\boxed{\frac{G_4}{(G_2)^2} = \frac{6}{k} \approx \frac{6}{N_{part}} \sim 1}$$

So perhaps this relation also holds for $v_2\{2\}$ and $v_2\{4\}$!

Important test of CGC; yes - no answer

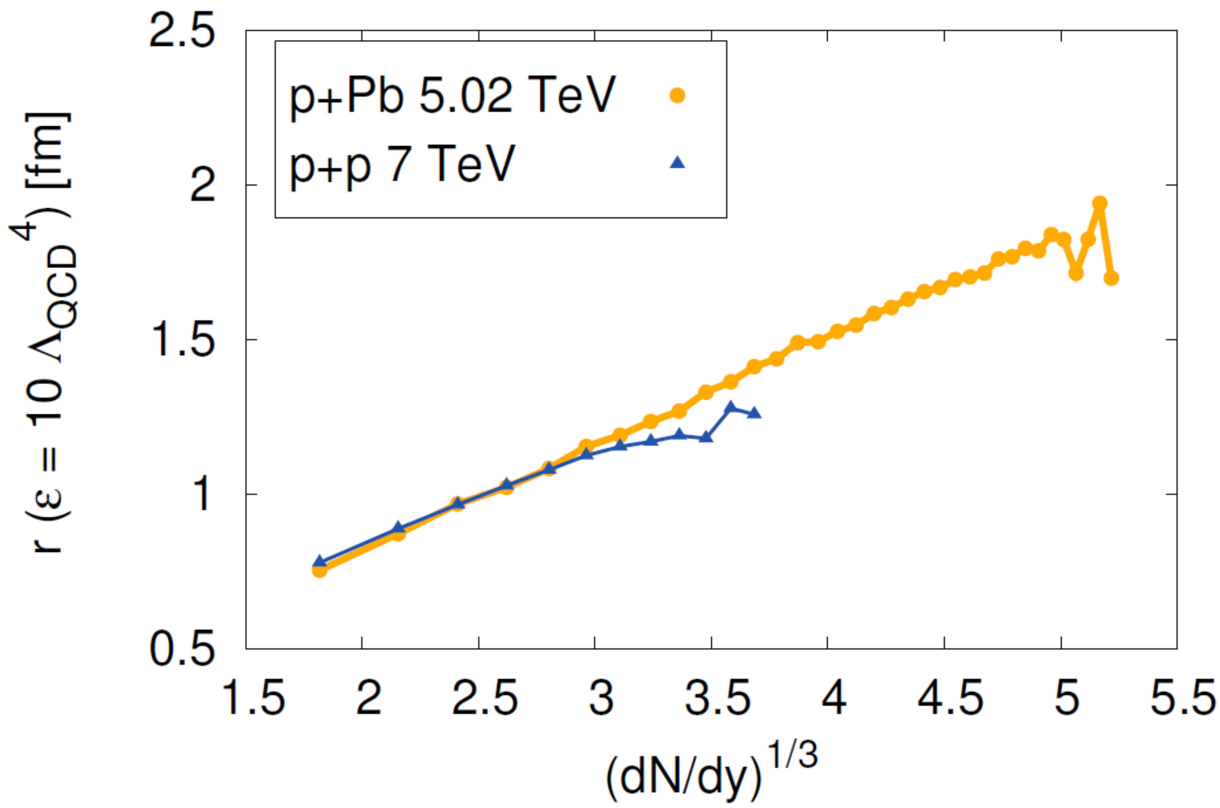
This is under investigation (K. Dusling, L. McLerran, R. Venugopalan)

AA and pp look very different. Where is pA ?



P. Bozek, W. Broniowski, PLB 720 (2013) 250

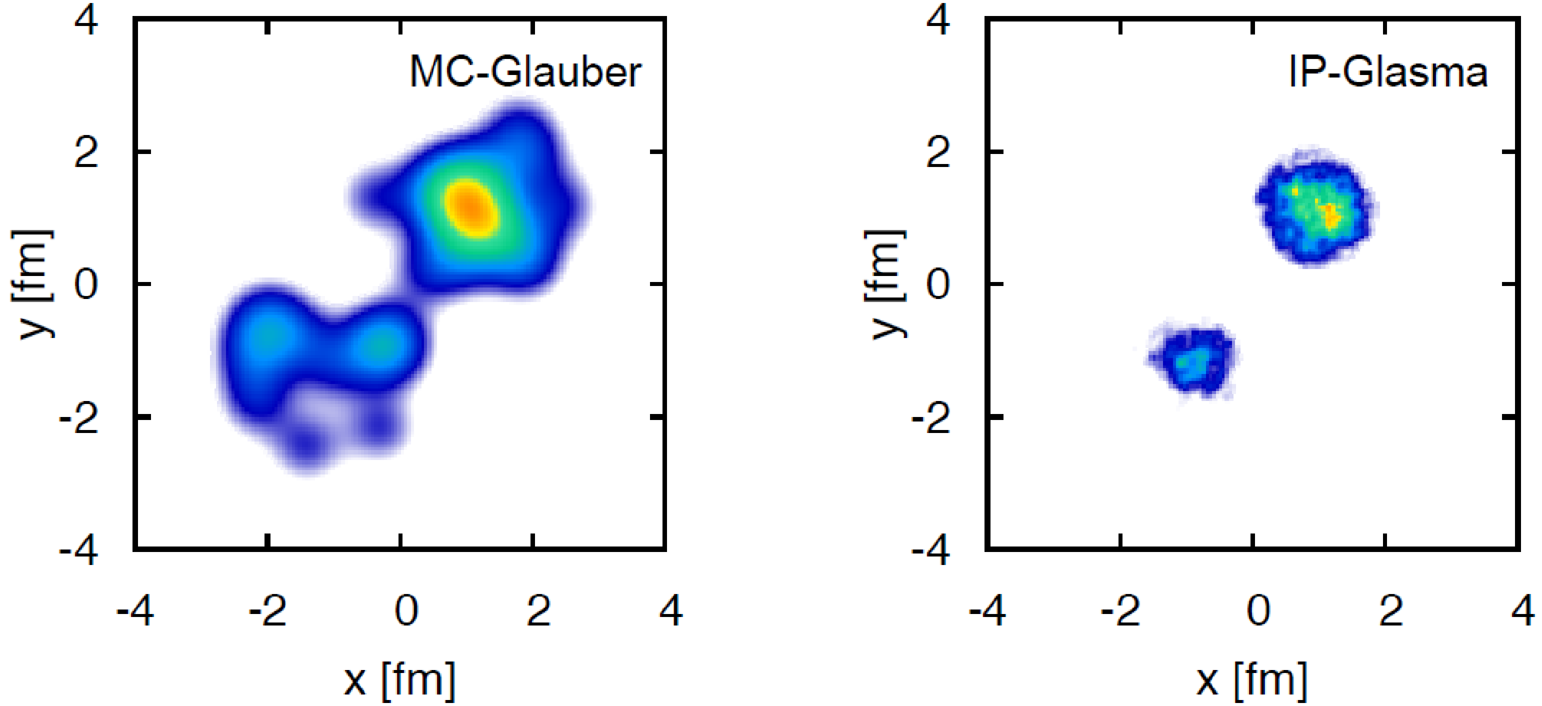
Size of the system in pp and pA



At the same number of particles HBT radii in pA should be very similar to those in pp, unless we have hydrodynamic evolution

AB, B. Schenke, P. Tribedy, R. Venugopalan, in preparation

As an example: Energy density for the same nucleon positions in dAu collision



Conclusions

- Surprising long-range near-side correlations in pp, pA and dA collisons
- CGC and “rough” hydrodynamic calculations agree with the data
- Standard Glauber model significantly overestimates eccentricities in pA collisions
- Scaling by PHENIX is rather questionable
- 4-particle correlation function is comparable to 2-particle one. Crucial test of CGC, in progress
- HBT radii in pp and pA should be very similar, unless hydrodynamic evolution is present